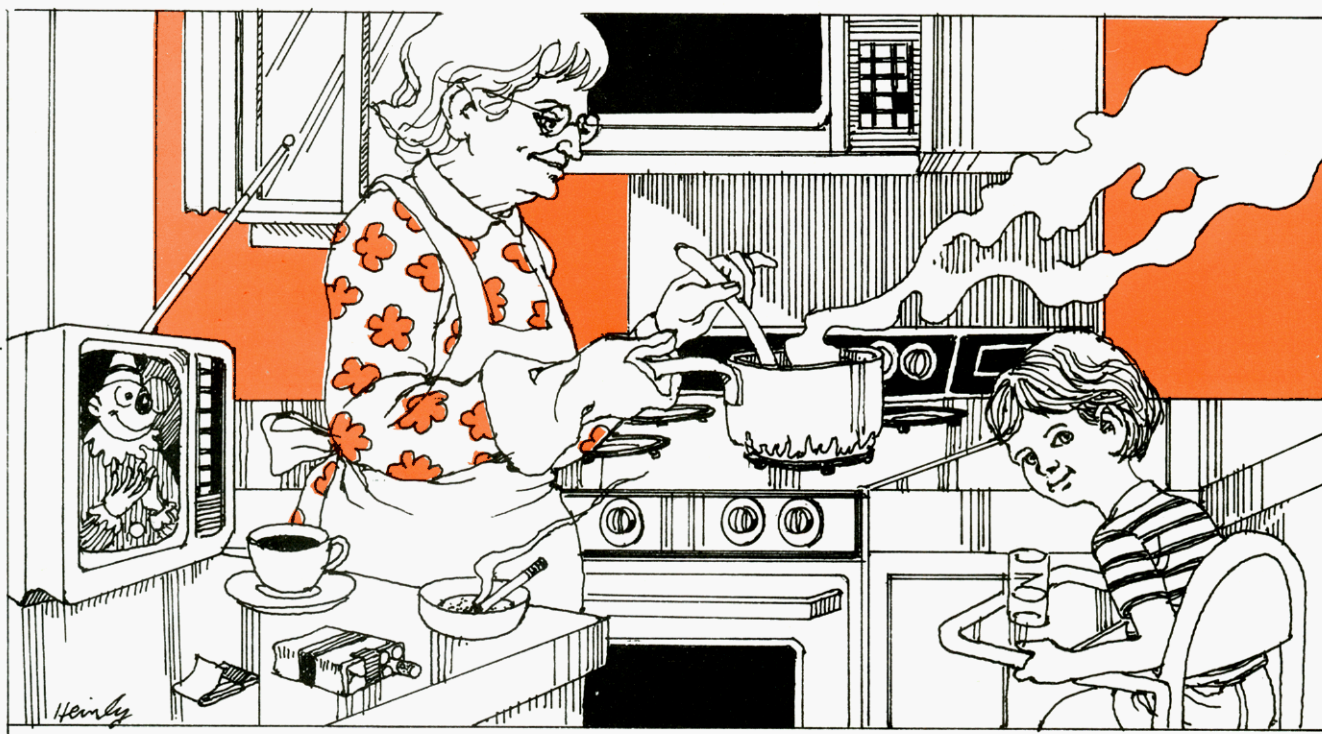


# Safeguarding indoor air quality

*California's lawmakers and health experts have a program to address the problem*



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Concern over the adverse health consequences of air pollution has focused traditionally on outdoor and occupational (primarily industrial) exposures. In response, federal and state programs have been created to protect public health from outdoor air pollution and to protect workers from dangerous air pollutants in the industrial workplace. The EPA is responsible for setting and enforcing National Ambient Air Quality Standards (NAAQS), which are designed to protect the general public from outdoor air pollutants to within an adequate margin of safety. The Occupational Safety and Health Administration (OSHA) enforces consensus standards

for industrial work environments, which are designed so that no employee will suffer material impairment of health or functional capacity. But no one federal agency has responsibility or authority for indoor air quality other than in the industrial workplace (1).

It is now recognized that nonindustrial indoor environments, such as private residences, offices, schools, and commercial and public buildings, are important places of air pollutant exposure. Although the magnitude of indoor health hazards is not now known, evidence continues to mount that measurement of indoor exposures is critical for the realistic assessment of air pollution's effect on health (2-5). It is known that indoor contaminant concentrations make significant contributions to time-weighted, integrated exposures. The implications of this finding for government efforts to protect public health through enforcement of NAAQS (outdoor air) and permissible exposure limits (workplace air) have not been explored fully.

The issue of unhealthful indoor air has received expanded attention in re-

cent years as scientists (2, 3, 6), professional organizations (7, 8), environmental and health groups (9), industrial associations (10), and the government (10, 11) have come to recognize the potential hazards. Despite accelerating interest in general, formal and comprehensive efforts have not been mounted by federal or state governments to determine the seriousness of potential health risks. An exception is the state of California, which has created and implemented the first state program devoted exclusively to the investigation of nonindustrial indoor air quality.

## Impediments to action

Several reasons account for society's tardy response to the issue of indoor air quality. First, the discovery of contaminated air in nonindustrial indoor environments is relatively recent. There are insufficient data on the number of people exposed, the pattern and severity of exposures, and the related health consequences. Until adequate data are accumulated to allow accurate estimates of health risks, decisions about appropriate public responses are not likely to

represent balanced choices between costs and benefits. The lack of a firm scientific basis for action is a major obstacle to the development of effective and reasonable government programs.

Second, because the scientific community has only recently recognized the potential hazards of indoor air pollution, the public is poorly informed about the issue. With the possible exception of antismoking groups, no organized constituency has formed to champion the cause of clean indoor air. The absence of such a coalition to lobby for healthful indoor environments means that there is little political urgency associated with legislation on indoor air quality. It is likely that an increase in public awareness and media attention would generate political pressure to provide legislators and regulatory officials with more incentive to take action.

Third, although they agree that indoor air pollution poses a potentially serious health problem, federal and state officials have been reluctant to act without specific statutory authority. The absence of clearly defined responsibility has caused a number of problems. These include a fragmented approach, with each agency addressing only that aspect of the issue within its purview; separate agencies instituting redundant research programs to suit their specific needs; and federal agencies assuming adversarial roles when they assess the effect of federal actions on indoor air quality (1). These problems should diminish as EPA assumes the lead in coordinating federal efforts to address the issues surrounding indoor air quality (12).

Adequate federal funding for indoor air research has not been available in the past, despite laudable efforts by the Department of Energy and the Consumer Product Safety Commission. Although the issue of indoor exposure is gaining increasing prominence, the prevailing climate is one of fiscal retrenchment and reducing regulatory burdens. It is little wonder that agencies have not been clamoring to take on added responsibility, because new programs inevitably mean additional demands on already shrinking budgets. The lack of federal money specifically for indoor air quality projects limits prospects for financial support, which in turn discourages new researchers from entering the field.

In addition, regulators are averse to being drawn into the nettlesome debate over whether government should intervene in private indoor spaces, especially residences. The question of the proper role of government in dealing with air pollution hazards inside public

### Why is safeguarding indoor air quality important?

On the basis of current knowledge, there are five major reasons that the investigation of indoor air quality is essential for the adequate evaluation of air pollution health risks:

- Most urban residents spend 80–90% of their time indoors; some groups, such as the elderly, the infirm, and infants, are inside almost all the time.
- Concentrations of some pollutants, such as asbestos, radon, tobacco smoke, formaldehyde, respirable particles, microorganisms, and many volatile organic compounds, are commonly higher indoors than outdoors.
- Monitoring studies have shown that because personal exposure to many pollutants is not characterized adequately by outdoor measurements, indoor values are consistently the best estimator of individual exposure.
- Indoor air quality may be adversely affected by trends toward reduced ventilation in buildings, increased use of synthetic materials, and increased reliance on unvented combustion appliances for space heating.
- Reports of inadequate indoor air quality and building-related illnesses from homeowners and office workers are a burgeoning problem for local, state, and federal health agencies.

and private buildings and the implications of voluntary vs. nonvoluntary risks have not been addressed adequately (13). Irrespective of the salient policy issues, the practicality of dealing with indoor air pollution through a regulatory approach is arguable (3, 13).

Finally, some regulatory officials and environmentalists fear that explicitly acknowledging the importance of indoor exposures in assessing health risks will weaken the case for ambient air quality standards. The industry argument goes like this: Because NAAQS are set to protect public health and because indoor sources of pollutants such as carbon monoxide, nitrogen dioxide, and respirable particles account for a substantial fraction of population exposure, efforts to reduce exposure should focus on indoor sources, rather than on requiring expensive controls on outdoor sources. One primary justification for more research is the need to evaluate the seriousness of indoor health hazards so that policy makers can more

readily assess the effectiveness of existing control strategies.

### Justification for action

There is ample precedent for government authority and responsibility to protect public health and welfare inside buildings. For instance, it is common practice to regulate construction and operation of public buildings. Government inspectors routinely enforce building codes, health regulations, safety rules, and fire ordinances. Although the government has an obligation to protect public health in indoor as well as outdoor environments, society cannot make informed choices about indoor air quality until adequate information is available.

The recognition that indoor air pollution may be a serious health hazard leaves policy makers with a familiar dilemma: How can government best fulfill its responsibility to safeguard citizens' health when the information on hand is incomplete and sometimes contradictory? Or more simply, now that we have discovered indoor air pollution, what do we do about it? The scientific basis of decisions about public action is weakened by a lack of data on the distributions of sources, building characteristics, daily activity and exposure patterns, indoor concentrations, and effects on health. Nevertheless, because data from several studies indicate that indoor exposure to some pollutants represents a significant health risk (2, 3), government efforts to define the magnitude of public health consequences are justified.

Justification for California's program focusing exclusively on nonindustrial indoor air quality is based on several factors. First, indoor air pollution can no longer be termed an emerging public health problem. Unhealthful indoor air is a fact of life for many people in California, and the situation may be worsening because of energy conservation measures and the increased use of synthetic building materials (2, 3, 6). Moreover, the federal response has been woefully inadequate, with efforts devoted primarily to dealing with crises caused by the use of asbestos in schools, formaldehyde emissions from urea-formaldehyde foam insulation, and elevated radon concentrations in homes built on phosphate lands in Florida and mining areas in Montana (2). There is a critical need in California for research to assess the nature of potential indoor environmental hazards.

Complaints about building-related illnesses in private and public buildings are a growing concern of many local and state health officials (14). In California, an increasing number of home-

owners and office workers are reporting problems with air quality. Yet because air quality in private residences, offices, schools, and public and commercial buildings is an institutional gray area, in which authority and responsibility at the state level are ill-defined, complainants are frequently told that little or nothing can be done. In general, states lack the authority, funding, and knowledge to present an adequate response to complaints about indoor air quality.

### Indoor air quality program

A budget change proposal (BCP) to establish an indoor air quality (IAQ) program within the Department of Health Services was approved by the governor of California for inclusion in his budget for the fiscal year beginning in July 1982. The BCP appropriated funds for eight permanent technical positions within the department's Air and Industrial Hygiene Laboratory. The IAQ program is the nucleus of a multidisciplinary effort to carry out investigations of identified and potential problems with the quality of indoor air.

In addition to the BCP, Assembly Bill 3200, which gives the Department of Health Services explicit responsibility for coordinating state efforts to assess, protect, and enhance indoor environmental quality, was approved by the governor in September 1982. As part of the California Health and Safety Code (15), this act established a legislative mandate for the IAQ program. It declares, "The people of the state of California have a primary interest in the quality of the indoor environment in which they live." The act also states

that "the public interest shall be safeguarded by a coordinated, coherent state effort to protect and enhance the indoor environmental quality."

The California IAQ program is responsible for promoting and conducting research on the determining factors of healthful indoor environments. Among the professional disciplines represented by our program staff members are chemistry, engineering, epidemiology, microbiology, psychology, and public health sciences. As part of the California public health effort, we have established strong ties with other state government groups, including the Human Monitoring Program, the Epidemiological Studies Section, and the California Occupational Safety and Health Program (Cal/OSHA).

The IAQ program is structured to obtain information about emission sources, ventilation effects, indoor concentrations, human activity patterns, exposures, health risks, control measures, and public policy options, so that informed policy decisions can be made about the need for government action. The process by which the issue of safeguarding indoor air quality is being addressed in the state is summarized in Figure 1.

The data are gathered by a variety of methods, including research conducted by staff members, review of the available scientific literature, participation in technical meetings, contractual agreements with outside agencies, cooperative research projects with other groups, and consultation with experts inside and outside the Department of Health Services. The aim is to assess the nature and extent of potential indoor

hazards in the state so that health risks can be evaluated adequately.

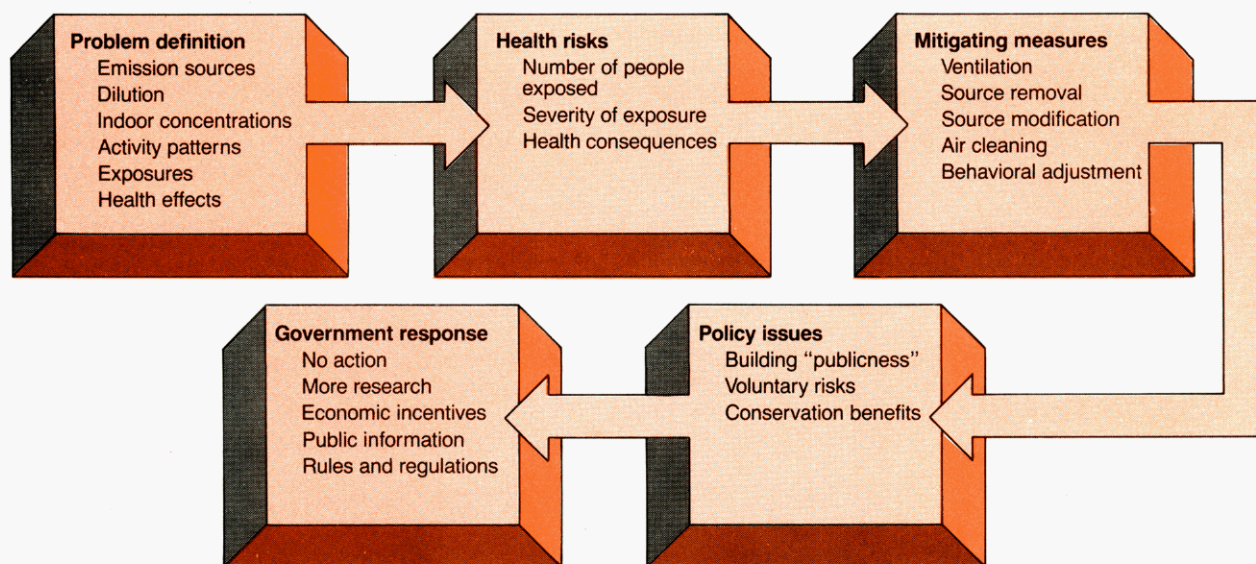
### Priorities

The IAQ program was not created as a knee jerk reaction to yet another newly recognized environmental problem. It was established without undue attention from the media or widespread public outcry about the need for government action. The program has no regulatory authority. Rather, its purpose is to initiate research necessary to define the essential components of healthful nonindustrial indoor environments. The program's goal is the timely acquisition of information to serve as the basis for a determination of the need for government response and appropriate forms of intervention (Figure 1).

Given the broad mandate outlined in Article 9.5 of the California Health and Safety Code and the paucity of data on hand, it is obvious that the current levels of funding and the number of professional staff are insufficient to address the spectrum of indoor health issues. It is therefore important to establish priorities so that available resources are focused on those issues likely to be of greatest concern. Important considerations in determining resource allocation include potential health risks (number of people exposed, severity of exposure, and health consequences), ongoing research by academic and government scientists outside the California health department (to avoid duplication), availability and suitability of sampling and analytical methods for important indoor contaminants, and the likelihood that identified indoor contaminants are a threat to the

FIGURE 1

### Addressing indoor air quality issues



health of citizens (based on assessment of building stock, demographics, and time-activity patterns).

Research on indoor exposures to selected gas phase and particulate phase organics, respirable particles, radon, and airborne microorganisms will be the major focus of our efforts for the next two to three years. In conjunction with attempts to define exposure distributions, data will be obtained on emissions from indoor sources and on the effects of ventilation on indoor contaminant concentrations. We also expect to carry out cooperative studies to investigate the relationship between indoor exposure and body burden (the amount of a given toxin in the bloodstream) for selected toxic chemicals. Because most people spend an average of 16 hours each day at home, and because in-home pollutant levels have been shown to exceed outdoor values for many contaminants, most of this research will be conducted in residential indoor environments.

Current resources also will be used to address the issue of building-related illnesses, especially in modern office buildings. Complaints from office workers about inadequate indoor air quality and associated symptoms, such as eye and throat irritation, headache, skin rash, and nausea, are a continuing source of study for California health officials. Because funds to carry out a systematic, multidisciplinary investigation of this issue are not now available, the program staff are working with Cal/OSHA to develop a coordinated mechanism for receiving and documenting building-related health complaints.

Resources also will be devoted to public education that fosters awareness of potential indoor air hazards and possible mitigating measures. Pamphlets and handbooks will be made available to consumers and homeowners about important indoor air issues. Further-

more, we have instituted a series of instructional presentations to professional groups, including building managers, physicians, architects, and industrial hygienists.

### Continuing activities

A major aspect of the IAQ program's task is to coordinate state activities affecting nonindustrial indoor environments. As shown in Table 1, many state agencies have jurisdiction over some part of the problem.

To ensure that the diverse groups deal with indoor air quality issues in a coherent and harmonious manner, the California Working Group on Indoor Air Quality was established. Representatives from concerned state agencies, primarily mid-level managers familiar with IAQ issues, meet periodically to discuss mutual interests and assess the needs of individual agencies. Discussions so far have focused on three major topics:

- the development of a coordinated system within the state to receive, document, and respond to building-related health complaints,
- the need to distribute information on important indoor air quality problems to individuals and groups, and
- the development of a standardized protocol that state, county, and local health officials can use to investigate building-related health complaints.

An important issue in addressing the health complaints of building occupants is the availability of private laboratories. As Sexton and Repetto point out, "Because air pollution levels in one building have virtually no effect on adjacent structures, the value as well as the cost of information remains largely private" (13). For example, the costs and benefits of maintaining adequate indoor air quality in private dwellings are borne by the occupants. The closed-loop cost-benefit cycle suggests the

possibility of a private demand for air-monitoring services, air-cleaning devices, and easy-to-use pollution monitors (13, 16).

The California IAQ program has neither the staff nor the resources to respond adequately to all, or even most, of the complaints by office workers and homeowners. To assess existing indoor air-monitoring capabilities within the private sector, a list of private companies and public agencies that routinely make contaminant measurements in nonindustrial indoor environments has been compiled. The list is available to all interested parties (16).

A number of research projects have started to address specific indoor air quality issues. Several investigations of air quality inside office buildings have been conducted in response to complaints about building-related illnesses (17, 18). When adequate funding is obtained, we hope to conduct a systematic study, in cooperation with Cal/OSHA, of the relationship between air quality in office buildings and workers' health.

There are a number of studies that focus on indoor residential environments. Among them are an investigation of airborne asbestos levels in homes with asbestos-lined furnaces, a comparison of two widely used methods to measure formaldehyde (19), and measurements of formaldehyde concentrations in 50 conventional homes in the San Francisco Bay area (20).

Other current studies include an indoor air monitoring project in 750 randomly selected mobile homes, focusing on measurement of formaldehyde and nitrogen dioxide concentrations (20, 21), and an investigation of the relative contributions of indoor and outdoor sources to in-home respirable particle concentrations. An environmental chamber study is currently under way in cooperation with Lawrence Berkeley Laboratory. Its purpose is to characterize particulate and organic emissions from major indoor sources (22, 23). In addition, indoor and outdoor particle samples from selected buildings are being analyzed for mutagenicity by means of a modified Ames test that uses special strains of histidine-dependent *Salmonella typhimurium* (18, 23).

### Determining success

As the field of indoor air quality research matures and the issues become more sharply defined, awareness of the necessity for an integrated approach to air pollution control will become more widespread. Findings from indoor air studies will come to the attention of the scientific, regulatory, and environmental communities, altering the perception that this is a peripheral issue and that

TABLE 1  
California state agencies concerned with indoor air issues

Agency	Jurisdiction
Department of Health Services	Lead agency for indoor air quality issues
California Energy Commission	Residential and nonresidential building standards
Cal/OSHA	Enforcement of OSHA standards in the workplace
Department of Food and Agriculture	Regulation of pesticide applications
California Air Resources Board	Outdoor air quality standards
Department of Consumer Affairs	Consumer products that are sources of air pollution
Office of the State Architect	Indoor air quality in state buildings
Department of Housing and Community Development	Indoor air quality in conventional and manufactured homes
State Department of Education	Asbestos in schools
Department of General Services	Indoor air quality in state buildings

indoor air quality is somehow separate from current government actions to limit exposures to outdoor air pollution.

All other factors being equal, the health effects of breathing air pollutants, such as carbon monoxide and nitrogen dioxide, are the same whether exposure occurs indoors or outdoors. Therefore, the justification for current control strategies, which focus almost exclusively on outdoor sources, is at odds with documented studies showing that elevated concentrations of both pollutants are common inside many residences and office buildings (3, 4). Ultimately, the success of the program will be determined by the degree to which safeguarding air quality in non-industrial indoor environments becomes an integral part of the California Public Health System.

### Complex policy issues

We expect the program to evolve as our knowledge about the determinants of healthful indoor environments expands. Emphasis will gradually shift from collecting data on exposure and body burden to applying accumulated information toward the mitigation of indoor air problems. More attention also will be directed to justifying direct government action to reduce indoor exposure, as well as to the effectiveness and suitability of alternative forms of intervention.

Maintaining healthful air quality in nonindustrial indoor environments is more than just a complex technical issue. It also raises complicated public policy questions about the proper role of government in safeguarding public health in private and public buildings (Figure 1) (13).

The compilation of information about pollutant concentrations, human exposure, and associated health hazards is not in itself sufficient to determine the appropriateness of government intervention. It is equally important to obtain data on individual perceptions of air quality, public awareness of health risks, and the extent to which this information influences private choices. A workable policy on indoor air quality must balance the need to protect individual privacy against government's responsibility to protect public health and safety.

Decisions about the need for public action to abate indoor air pollution must address several major policy issues: Does the role of government depend on the degree of public access to, and occupancy of, a particular building? If so, what is an appropriate response to air quality problems in private buildings? Is consideration of the difference between voluntary and involuntary risks

important for choices about government intervention? What are the trade-offs between energy conservation measures and indoor air quality? Should the emphasis be on protecting building occupants from long-term chronic exposures or short-term peak exposures? If government intervention is justified, what forms are appropriate?

California has begun to address the entire range of technical and policy issues by establishing a permanent IAQ program. Its goal is to acquire data necessary to define the components of healthful indoor air, to evaluate the applicability of available mitigating measures, and to assess the relative merit of policy alternatives.

### Acknowledgment

Assemblywoman Sally Tanner, chairperson of the California Assembly Committee on Consumer Protection and Toxic Materials, was instrumental in creating California's IAQ program. She and other members of the committee have been influential in drawing public attention to the need for safeguarding indoor air quality. We also thank J. Heslep, D. Lyman, and C. Langston of the California Department of Health Services for their invaluable support in setting up the program, and members of the staff who assisted in implementing the program, including P. Flessel, R. Stanley, L. Pierce, S. Twiss, M. Petreas, K. Liu, L. Webber, S. Hayward, H. Okamoto, J. Stratton, G. Kulasingam, A. Kelter, and R. Neutra.

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